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SEM Observation on a Fragment of Triassic Fish Scale from Okinawa, Japan

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Introduction

Since ISHIBASHI (1969) found Triassic deposit in Motobu Peninsula of Okinawa-jima, some fossil remains of various invertebrates have been reported from the area. The bivalve *Halobia* (see KOBAYASHI and ISHIBASHI, 1970), nautiloids (ISHIBASHI, 1977a), and conodonts (KOIKE and ISHIBASHI, 1974) were described from Triassic Nakijin Formation in the Motobu Peninsula. Here we report on a fragment of fish fossil with rhomboid scales, which was probably derived from a bed of the same formation. Before going further, we like to express our sincere gratitude for their cooperation and advice, to Mr. Masaki MATSUKAWA of Faculty of Sciences, Ehime University, and Dr. Yasuji SAITO of the Department of Geology, National Science Museum. Dr. Hans-Peter SCHULTZE of the University of Kansas read the manuscript and gave us crucial advices.

Stratigraphic Notes

Locality: The fish fossil was collected in December, 1970, at the locality on the road from Bise, southeastward to Toyohara village, in the northwestern region of Motobu Peninsula, Okinawa-jima (Fig. 1). Previously ammonites were collected from calcareous siltstone at the middle of the cliff (about 2 m high) at the east side of the road. The fish fossil was found among numerous scattered rock fragments below the exposed bed (Fig. 2) at the locality (the dip strike of the bed was N24°W, 30°S).

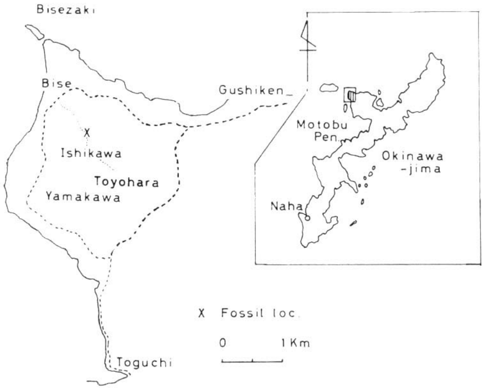


Fig. 1. A map showing the locality where the fossil fragment from a Triassic bed was discovered in Okinawa.

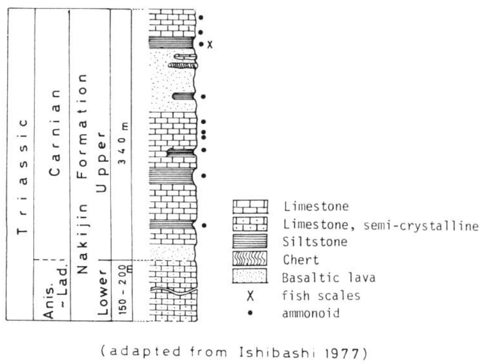


Fig. 2. The columnar section of the stratigraphic sequence indicating the bed yielded the fossil fish.

Age: According to ISHIBASHI (1977b), the horizon of the bed containing the fossil belongs to the upper member of Nakijin Formation, which is a marine deposit yielding following ammonites: *Mojsisovicsites*? sp., *Helictites* sp. *Thisbites* sp., *Tropiceltites* cf. *T. columbianus* (MCLEARN), *Placites* aff. *P. oldhami* (MOJSISOVICS). In the international scale, this bed is considered as the Upper Carnian deposit of the Late Triassic Era (Fig. 2).

Description

Material: Catalogue no. NSMT-PV 16856. A fragment of fish with about 40 overlapping scales.

The color of the preserved scales is dark brown, and their size is approximately 5.0 mm $\times$4.5 mm. The posterior half of the each scale is exposed, and low parallel ridges which are 70 $\mu\sim$80 μ high, are developed (Pl. 1–1) in this region. These ridges are about 1300 $\mu\times$250 μ in their sizes and semicircular in their cross section. Between ridges, there are grooves which are about 100 μ in their width. The ridges give serrated appearance to scales, as the ridges slightly extend beyond grooves at the margin.

The ridges become lower and gradually disappear toward the unexposed portion of the scale. The unexposed portion is densely covered by fine striations which run longitudinally to the scale axis. The thickness of the scales is about 100 μ at the exposed portion, and about 150 μ at the unexposed portion.

Ridges: The surface of the unexposed portion of the scales is partially broken off, and some depressions are recognized. The state of the preservation is not necessarily good. Their surface is smooth.

The mineral layer covering the ridges is very thin and uniform (10 mm thick), and can be considered as the enameloid layer (Pl. 1–5 ~ 6). Dentine tubules are unrecognizable within the spongy layer immediately below the enameloid layer. The large part of the scales consists of spaceous spongy bone (Pl. 1–5 ~ 6). Small round pores are recognized on the surface of the grooves, though they are probably not a part of the original structure.

Vascular canal in the transitional zones: In the area between exposed posterior part and unexposed anterior part, small pores of the elliptical shape in the size 8.5 μ $\times$ 6.5 μ are present (Pl. 2–1 ~ 2). The wall of this opening penetrates into the inner space (Pl. 2–3). Around the opening aggregated granules are distributed like islands. These small pores are linearlly arranged with spaces about 50 μ in the grooves which run parallel on the surface of the unexposed portion of the scale. There are shallow flat grooves which run toward the openings of the pores. They cross parallel ridges and are divided into branches. Granules arranged like islands are observed along the grooves. This probably suggests that the pores are pathways of a kind of vascular canal.

This type of the structure is not observed in the posterior portion of the scale. The density of the distribution of these pores is greatest in the area of 300 ~ 400 μ wide in front of the transitional zone between the exposed and unexposed portions.

In the area anterior to this transitional zone, grooves which run parallel to the long axis of scales become less developed, and broadly spaced low ridges start to appear (Pl. 2–4). On the surface of these ridges, shallow grooves which run parallel or perpendicular to the axis are recognized. In the higher magnification it becomes apparent that the surface of the ridges and grooves are densely covered with granular structures distributed like islands, but grooves themselves are consist of smooth striation of a few microns wide and their branches. Some parts of the branches are connected to small pores (4 $\mu \times 2$ μ in size).

WESTOLL (1936) and FORSTER-COOPER (1937) pointed out that the cosmine layer at their surface of cosmoid scales is repeatedly reabsorbed and redeposited in different physiological conditions, and the thickness of the cosmine layer changes periodically. There is a possibility that the fossil scales described here are at the similar stage when the cosmine layer was reabsorbed.

The surface of the ridges which are developed in the posterior exposed portion are smoother without special ornamentation than the surface at the transitional zone and anterior unexposed portion. This probably indicates that the surface of the ridges was exposed above the surface of the epidermis, as in the case of spinules on the scales of Recent coelacanth, *Latimeria chalumnae* (see FUKUDA *et al.*, 1978).

On the surface of the transitional zone of the scales, fine granules are distributed like islands, and among these islands of granules small pores to which fine, complicatedly branched grooves run are observed.

In the cosmoid scale of *Porolepis uralensis*, which was yielded from Lower Devonian bed in Ural region, numerous round pores are recognized at the surfaces, but no branched grooves were present. These pores were considered to be pores for mucous secretion (BYSTROW, 1959).

In the scales described here, the size of the pores is 8.5 μ in the longest diameter and provided with branched grooves. This indicates that these pores are not for mucous secretion, but vascular canals which penetrate scales. Since these pores are present on the surface of the transitional zone and unexposed portion, they must had been covered with the epidermis. These vascular canals send fine branches to the spongy bone and the epidermal tissue, and nourish them. Spongy bones must have functioned for the development of the ganoine layer on one hand, and as a cushion for absorbing the external pressure on the other hand. The dense bony layer at the base is the supporting structure of the scales.

Anterior unexposed portion of the scales: In the greater part of the anterior unexposed portion of the scales, the upper layer was pealed off by the weathering, and the lower layer of the spongy bone is exposed (Pl. 3–1 ~ 2). This spongy bone occupies about one third or a half of the area in the cross section of the scale, and below this layer the dense bone in lamella continues (Pl. 3–3 ~ 4). The spongy bone consists of bony structure in V or X shapes (100 $\mu \times 10$ μ in size) (Pl. 3–5) which intermingle together. On the surface of the bony structure, minerals in polygonal shapes are attached (Pl. 3–6). The border between the spongy bone and the layer of dense bone below is not clearly defined. In the inside of the bony layer, round or elliptical spaces are distributed. This layer of spongy and dense bone is the basic structure of the fossil scales reported here. This nature does not differ in the posterior exposed portion of the scales (Fig. 3–A B).

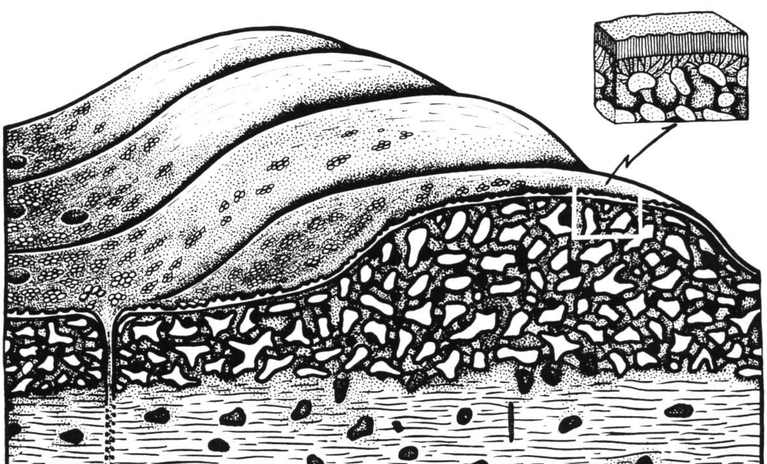


Fig. 3. A schematic drawing of the reconstructed structure of the fossil scale from the Triassic bed in Okinawa.

Consideration

The dense enameloid layer covering the outer surface of the fossil scales are very thin. This is probably not the result of weathering or fossilization process, but the basic structure of these scales, for the fine granules on the surface at the transitional zone are preserved. The structure of the fossil scales examined here appears to resemble ganoid scales having the thin enameloid layer, thick spongy bone, and dense bony layer (GOODRICH, 1908; ØRVIG, 1969; SCHULTZE, 1977). A thin ganoin layer direct on the bone is characteristic for the lepidosteoid type of ganoid scale (SCHULTZE'S personal communication). In the structure the characters which are diagnostic to cosmoid scales, such as small pores which open to the enameloid surface, and dentine tubules finely branched are unrecognized. Probably, these features are not disappeared or became obscure because of the recrystallization of minerals or secondary substance within the tissue.

This fossil fragment represents one of the earliest Osterichthyes reported in Japan. The nature of its scale indicates that the specimen probably belongs to one of the species of fishes which has not been recorded from Japan.

References

BYSTROW, A. P., 1959. The microstructure of skeleton elements in some vertebrates from Lower Devonian deposits of the U.S.S.R. *Acta. Zool.*, **40**: 59–83.

FORSTER-COOPER, C., 1937. The Middle Devonian fish fauna of Achanarras. *Trans. R. Soc. Edinb.*, **59**: 223–239.

FUKUDA, Y., N. KAWAMOTO, I. OBATA, & Y. KANIE, 1978. Notes of observation by scanning electron microscope on a scale of *Latimeria chalumnae*. *Sci. Rep. Yokosuka City Mus.*, (24): 45–50, pls. 8, 9. (In Japanese with English abstract.)

GOODRICH, E. S. 1908. On the scale of fish, living and extinct, and their importance in classification. *Proc. zool. Soc. Lond.*, 751–774.

ISHIBASHI, T., 1969. Stratigraphy of the Triassic Formation in Okinawa-jima, Ryukyus. *Mem. Fac. Sci., Kyushu Univ.*, [*D*], *Geol.*, **19**(3): 373–385, pl. 53.

———, 1970–75. Upper Triassic Ammonites from Okinawa-jima. *Ibid.*, **20** (2): 195–223, pls. 26–29 [1970, Part 1]; **22** (1): 1–12, pls. 1–3 [1973, Part II]; **22** (2): 193–213, pls. 27–28 [1975, Part III].

———, 1977a. A New Upper Triassic Nautiloid from Okinawa-jima. *Ibid.*, **23** (3): 409–416 pl. 65.

——— 1977b. Late Triassic Ammonites 1–6. *Atlas of Japanese Fossils*, (47): 277–282, Tsukiji Shokan, Tokyo (in Japanese).

KOBAYASHI, T. & T. ISHIBASHI, 1970. *Halobia styriaca*, Upper Triassic pelecypod., discovered in Okinawa-jima, the Ryukyu Islands. *Trans. Proc. Palaeont. Soc. Japan*, [N.S.], (77): 243–248, pl. 26.

KOIKE, T. & T. ISHIBASHI, 1974. Upper Triassic Conodonts from Okinawa-jima. *Ibid.* (96): 433–436, pl. 57.

ØRVIG, T., 1969. Cosmine and cosmine growth. *Lethaia*, **2**: 241–260.

SCHULTZE, H–P, 1977. Ausgangsform und Entwicklung der rhombischen Schuppen der Osteichthyes (Pisces). *Paläont. Z.*, **51** (3/4): 152–168.

WESTOLL, T. S., 1936. On the structure of the dermal ethmiod shield of *Osteolepis*. *Geol. Mag.*, **73**: 157–171.

Explanation of Plates

Plate 1

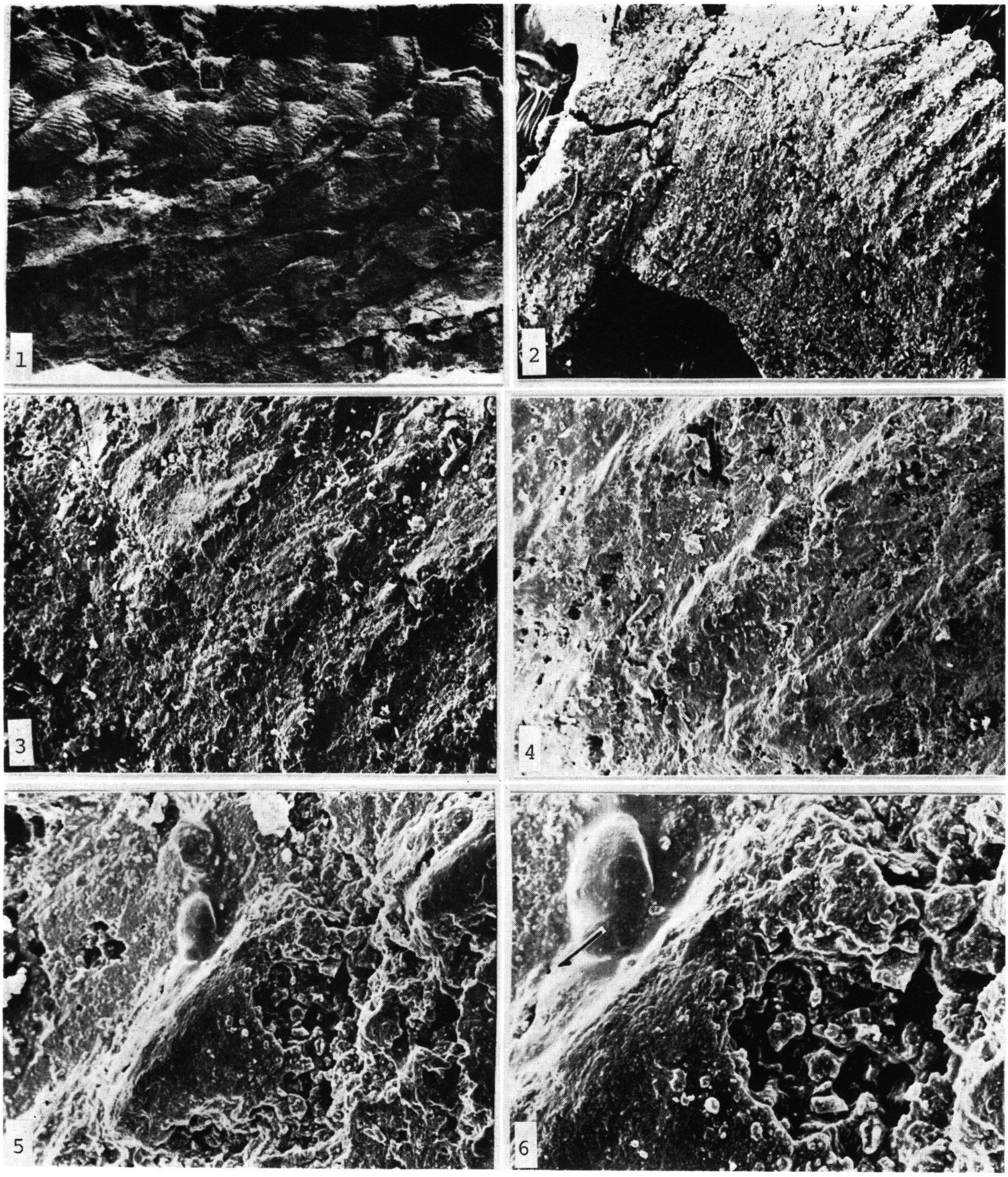
Triassic fossil fish scales from Okinawa. NSMT-PV 16856. 1, total appearance of the fossil fragment (×2); 2, the portion with ridges is the anterior unexposed region, and the thick portion is the posterior exposed region. (×40); 3～4, The thick portion (3, ×80; 4, ×100); 5, the weatherd spongy bone in the inside of the thick portion (×350); 6, the very thin enameloid layer on the top of the spongy bone is shown, and the arrow at the left indicates a very small pore which is probably not an original structure of the scale (×750).

Plate 2

Triassic fossil fish scales from Okinawa. NSTM-PV 16856. SEM micrography showing openings of the vascular canals on the surface of the transitional zone and the exposed region. 1～2, openings of vascular canals arranged in approximately equal spaces (1, ×560; 2, ×750); 3, openings of the vascular canal at the transitional zone with granules distributed like islands and making pathways to branches (×3500); 4 weak ridges and fine grooves at the unexposed surface (×80), and the opening (arrow) of the vascular canal (5, ×2900; 6, ×1100).

Plate 3

Triassic fossil fish scales from Okinawa. NSTM-PV 16856.
1～2, porous spongy bone at the unexposed region (1, ×110; 2, ×220); 3, the spongy bone and the dense lamellar bone (arrow) (×300); 4, a cross section of spongy bone (×1000); 5～6, the ridge of spongy bone in shapes of V or X (polygonal subject at the ridge surface appears to be recrystalized mineral) (5, ×160; 6, ×2900).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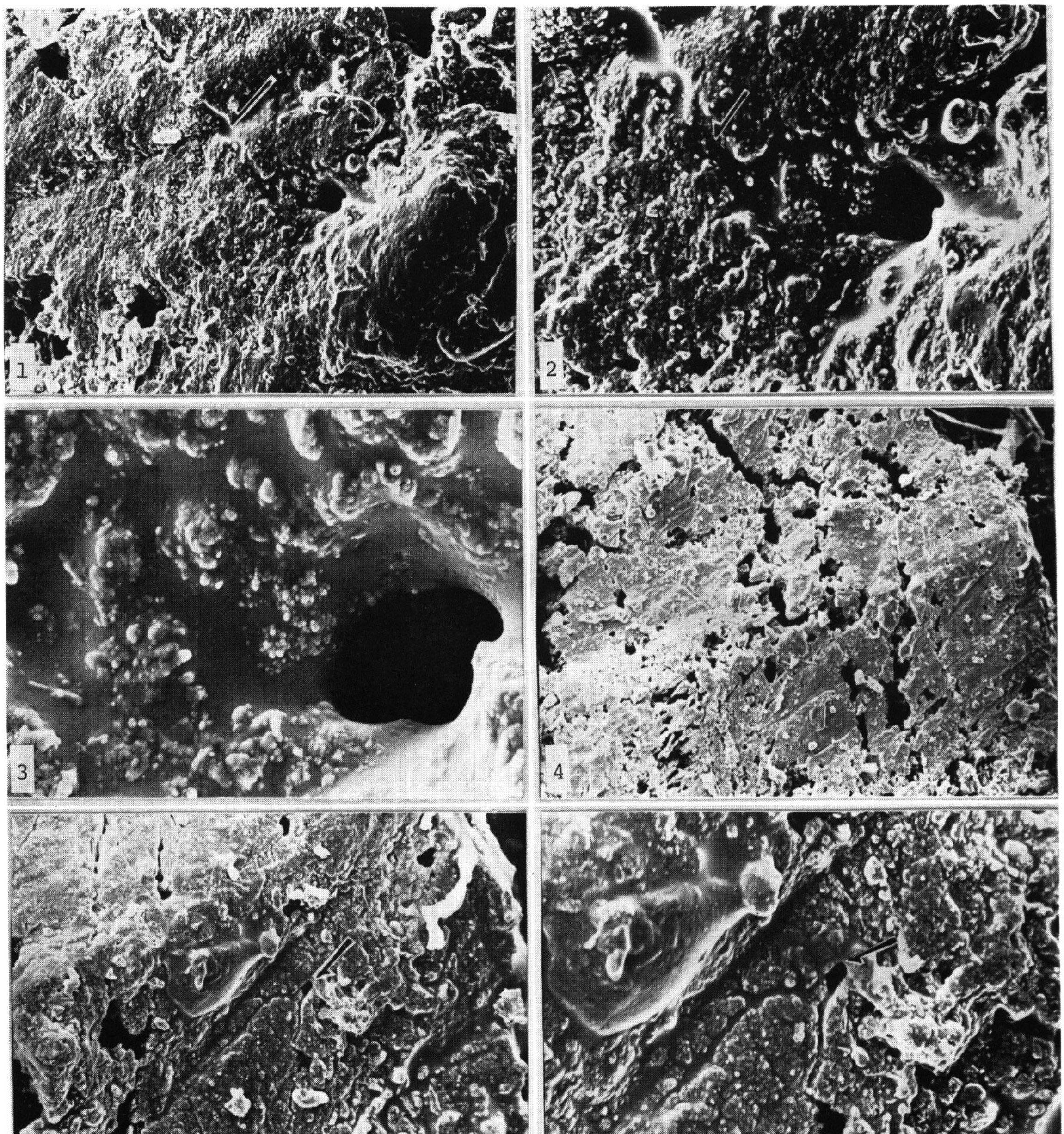
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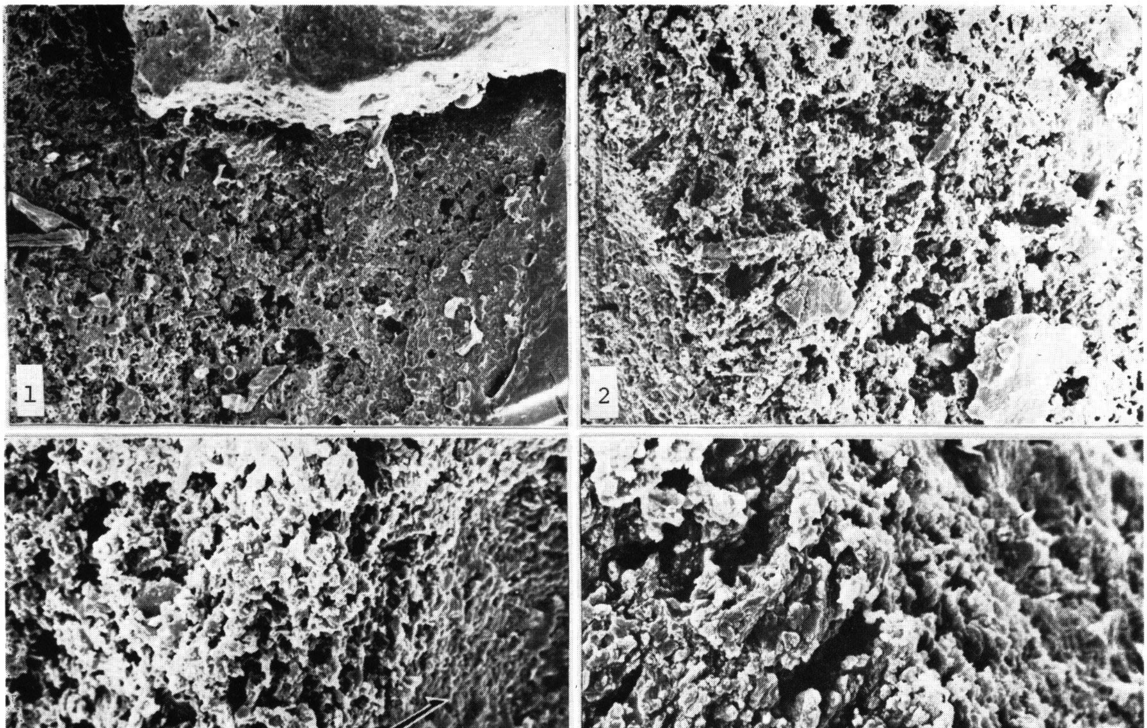
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